How Did the Earth Form?

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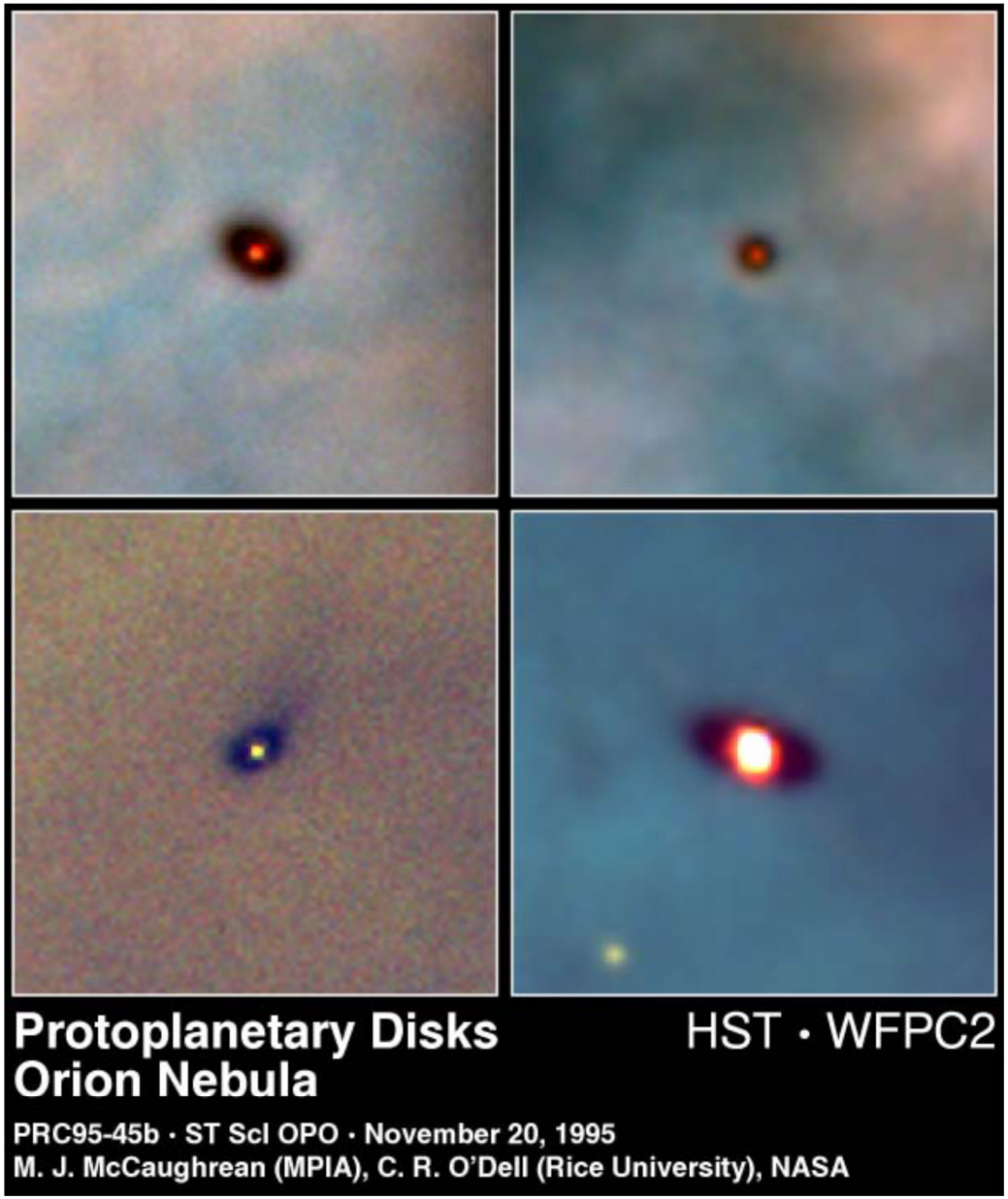
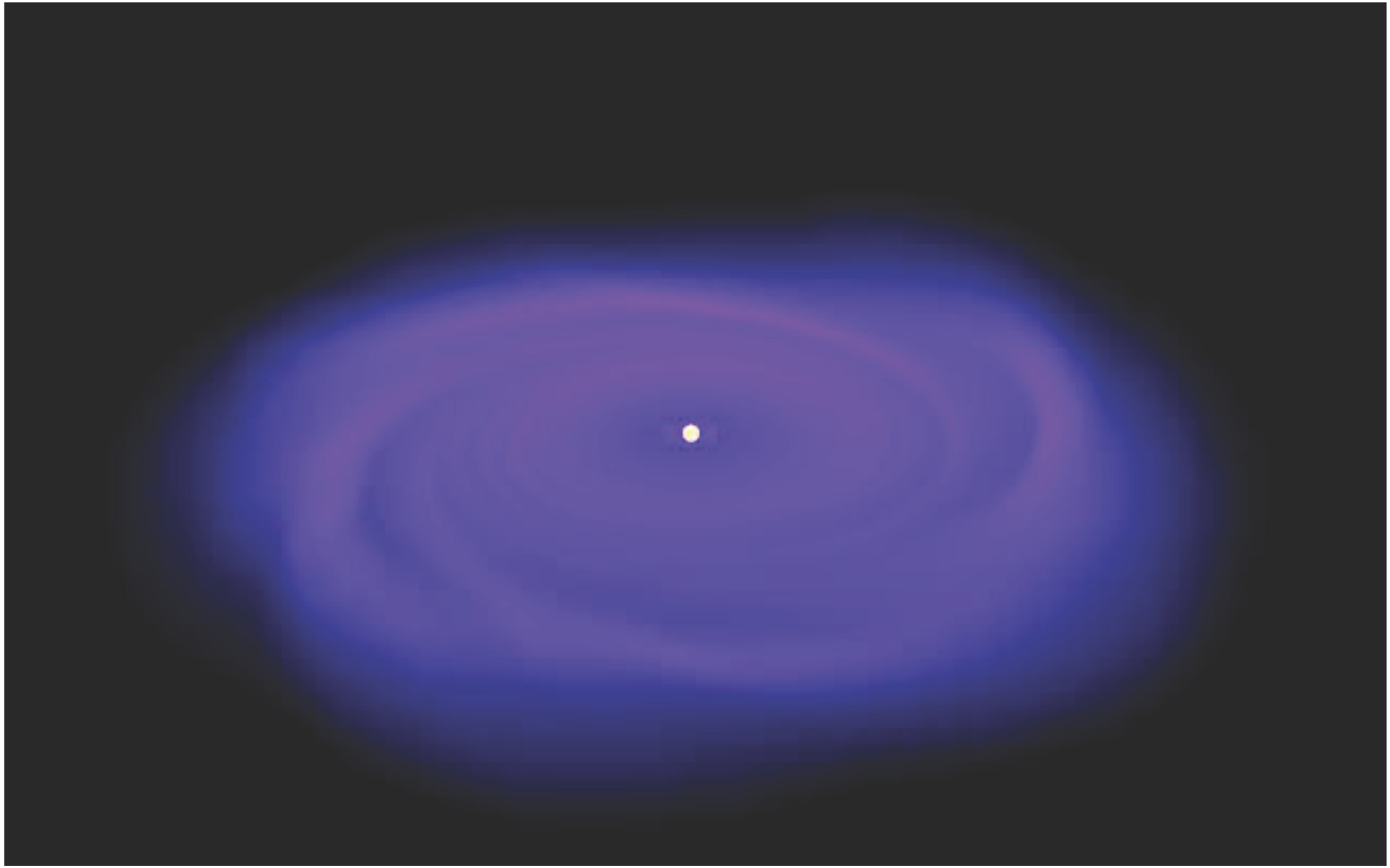
(Apollo 8)

Proto-planetary Disks

- What we know (or think we know)
  - All of the planets in the solar system nearly in a plane.
  - Disks of dust and gas detected around nearby forming stars.
  - Simulations of proto-planetary disks show planets growing.
- Ergo, planets form in disks of material around stars.



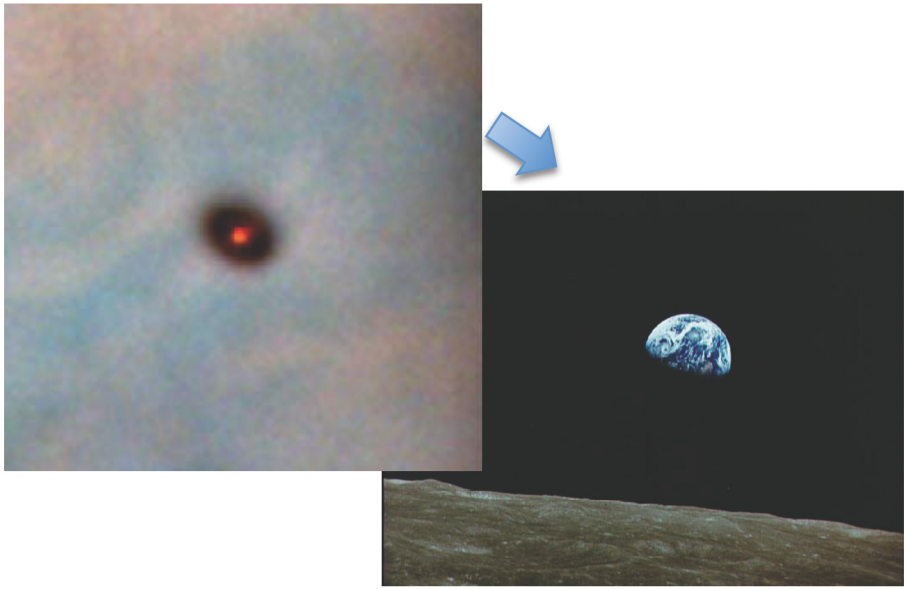
Simulation of Planet Formation

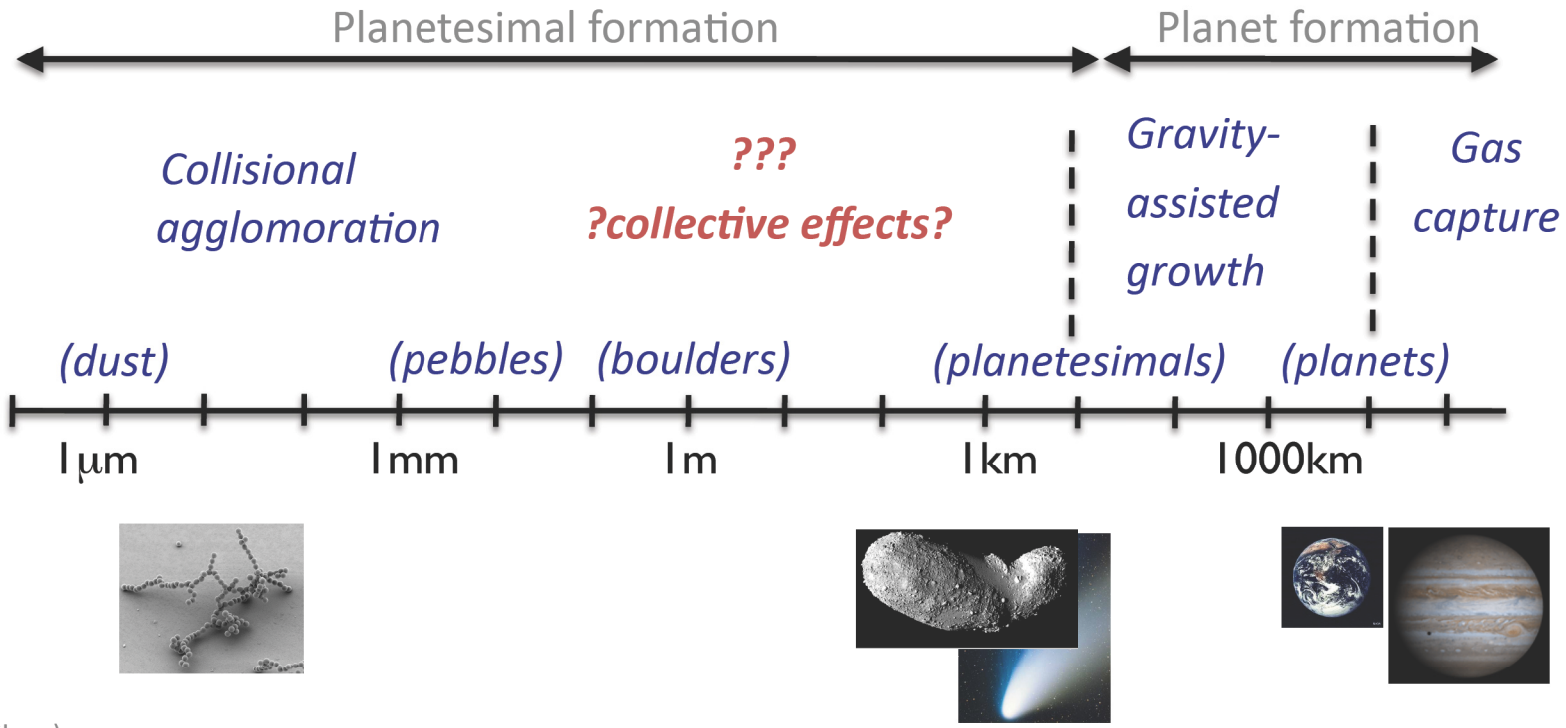


Proto-planetary Disks

From Dust to Planets

(what we think happens …)





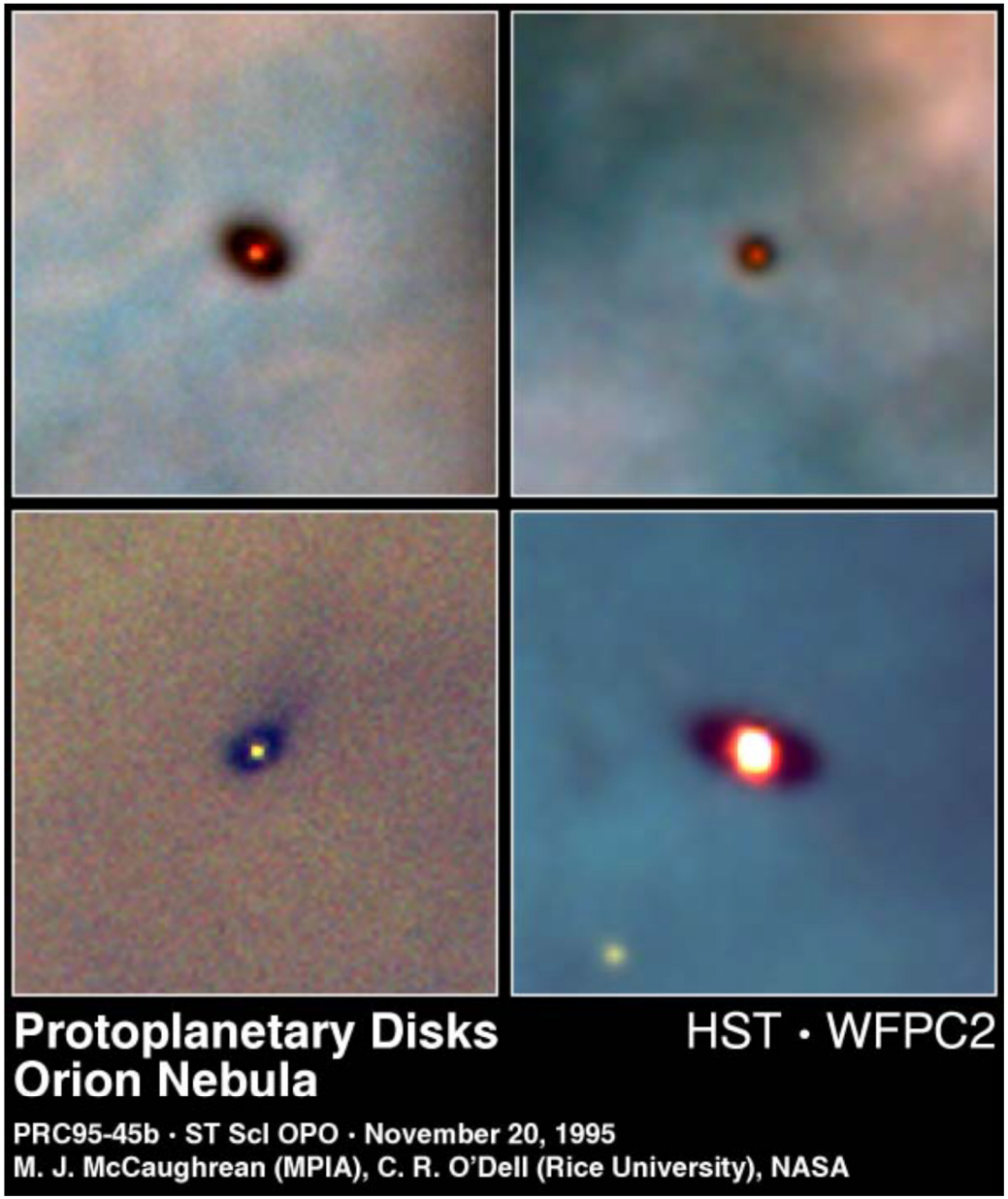
(From D. Wilner)

Proto-planetary Disks

- *All of the planets in the solar system nearly in a plane.*
- *Disks of dust and gas detected around nearby forming stars.*
- *Ergo, planets form in disks of material around stars.*
- Want to understand how planets grow in proto-planetary disks

➢ Disks are **opaque** to visible light.

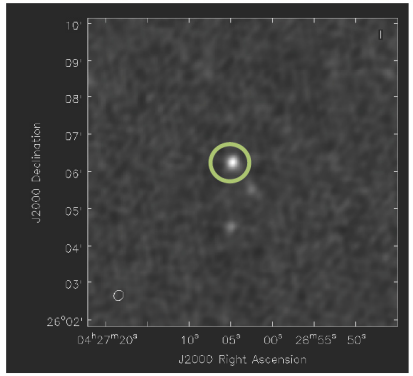
➢ Want **observations at 5 GHz to 1 THz** ➔ mm- and cm-wavelength radiation, comparable to size of particles.



Radio Astronomy Service and Planet Formation

Expanded Very Large Array
(1 GHz to 50 GHz; US-Canada-Mexican partnership)

Atacama Large Millimeter/submillimeter Array
(100 GHz to 1 THz; US-European-Japanese partnership)



EVLA observations: ongoing—60+ nearby stars with disks
(example shows C-band observations of disk around star DG Taurus, illustrating decimeter-sized particles in the disk)

ALMA status: in commissioning

Formation of Planets and the Radio Spectrum

Understanding the formation of planets, and how we came to be, requires

- Infrared telescopes in space;
  - … and X-ray telescopes in space?
    - E-S: 2110–2120 MHz, 7145–7190 MHz, 34.2–34.7 GHz
    - S-E: 2290–2300 MHz, 8400–8450 MHz, 31.8–32.3 GHz
- Telescopes on the ground operating from 5 GHz to 1 THz.